PC

RESTRICTED CIRCULATION

This paper is not an official document; it is for information only and must not be quoted in any printed publication.

Agricultural Memorandum No. 898

Climate of Kent with special reference to horticulture

This paper outlines the main features of Kent's climate, paying special attention to meteorological factors important to horticultural production. Data for other major fruit growing areas in Britain, namely Hampshire and the south coast, East Anglia, the Midlands and the south-west peninsula (together with data for the Netherlands representing the European mainland - where available) are included in the Appendices for comparison purposes.

Introduction

The county can be divided into three broad topographical regions. The North Downs running approximately south-east to north-west form the major uplands of the area separating low lying areas to the north-east from the undulating lands of the Weald to the south-west. Inland of Dungeness, the so-called Romney Marsh forms an extensive area of flat, often poorly drained ground.

The character of farming in Kent is a direct result of the county's geographical and geological make-up; a vast range of soils has enabled a diverse range of agricultural and horticultural enterprises to develop. Close proximity to the European mainland inevitably results in the weather and climate showing some signs of continental influences. Hot summers, for example, in inland Kent (as in other parts of south-east England) may well be warmer than the south-west of England, while heavy winter snowfalls during easterly or northerly winds are not uncommon. The county's east coast location also means that it is less directly influenced by the Atlantic in winter than is the south-west, for instance.

Climate

The climate is discussed in terms of :

i. temperature.
ii. frost liability.
iii. accumulated day degrees and ontario heat units.
iv. soil temperatures and growing season.
v. sunshine and radiation.
vi. windspeeds.
vii. rainfall.
viii. potential transpiration.
ix. soil moisture deficit and irrigation need.
x. spring work days.

i. Temperature

Table 1 summarises temperature at 3 sites in the county; corresponding values for Southampton, Stratford-upon-Avon (the nearest available long-period met. site to the Vale of Evesham), Terrington St. Clement, Penzance and Vlissingen (lying within an area of intensive horticultural production along the west coast of the Netherlands) are given in Appendix 1(a).

Table 1

Average daily maximum, minimum and mean temperatures °C, 1941 - 70

	East Malling 37m			Goudhurst 85m			Dover 6m		
	max	min	mean	max	min	mean	max	min	mean
JAN	6.2	0.4	3.3	5.9	0.0	2.9	6.4	1.9	4.1
FEB	6.8	0.6	3.7	6.6	0.1	3.3	6.7	1.9	4.3
MAR	9.9	1.8	5.9	9.9	1.4	5.7	8.9	3.3	6.1
APR	13.4	3.9	8.7	13.4	3.3	8.3	12.1	5.6	8.9
MAY	16.8	6.3	11.5	16.7	5.9	11.3	15.2	8.5	11.9
JUN	20.1	9.3	14.7	19.7	8.6	14.1	18.2	11.3	14.7
JUL	21.7	11.4	16.5	21.2	10.9	16.1	19.9	13.4	16.7
AUG	21.2	11.1	16.1	20.8	10.6	15.7	20.2	13.5	16.9
SEP	19.0	9.4	14.2	18.7	9.1	13.9	18.7	12.1	15.4
OCT	15.1	6.3	10.7	14.8	6.3	10.5	15.1	9.3	12.2
NOV	10.0	3.3	6.7	9.7	3.0	6.3	10.5	5.6	8.1
DEC	7.5	1.4	4.5	7.2	1.0	4.1	7.9	3.2	5.5
YEAR	14.0	5.4	9.7	13.7	5.0	9.3	13.3	7.5	10.4

The earliness of the south-west region results mainly from the moderate temperatures in late winter and early spring which favours a long growing season. Minimum temperatures at Dover during this time are up to 2.5°C cooler than at Penzance on average, whilst inland areas of Kent have temperatures comparable with the W. Midlands and East Anglia throughout the year. Average daily maximum and minimum temperatures for East Malling, Dover and Penzance are plotted in fig. 1.

Near to the Kent coast, nights tend to be warmer than inland by as much as 3°C or more on average in late summer and early autumn; daytime temperatures on the other hand, tend to be higher inland being up to 2.5°C warmer than coastal sites on average during the summer months.

ii. Frost Liability

An air frost is defined as occurring when the 'screen'* air temperature falls below freezing point. Areas prone to radiation frost are those into which cold air drains at night and from which air flow is restricted due to hedges etc.; a slope of 2° is considered sufficient to produce such movement (Roe (1980) showed that radiation frosts are by far the most frequent type of frost, although wind frosts may be important in more exposed areas). The major areas prone to radiation frosts (Fig. 2) occur inland in the valleys of the north-east slope of the Downs notably the Darent Valley, parts of the Medway Valley north of Maidstone and the Great Stow valley north of Canterbury.

---

* Air temperatures are measured at a height of approximately 4 feet above ground in a white Stevenson screen.

Along the coast the first autumn frosts usually occur around mid-November and the last spring frosts generally before mid-April, compared with early November and late April respectively in inland areas. The average and extreme dates of first and last frosts at Wye and Faversham are given in table 2.

Table 2

Average, standard deviation and extreme dates of first and last frost.

		First Frost			Last Frost		
Station	Period	Average	SD	Extremes	Average	SD	Extremes
Wye	1959-79	6 Nov	12	14 Oct and 29 Nov	20 Apr	19	13 Mar and 3 Jun
Faversham	1959-78	14 Nov	26	6 Oct and 5 Feb	23 Apr	16	22 Mar and 21 May

These figures* refer to reasonably well-exposed sites so that areas with poor air drainage (eg. Goudhurst) will have a shorter frost-free period while areas with good air drainage and a southerly aspect will have a longer frost-free period. The ameliorating effect of the coast is quite marked with Margate having a frost-free season of almost 9 months (comparable to Plymouth Mount Batten) while only a few miles inland at Manston this period is reduced to 7 months. In fact the potential lateness of spring in Kent is one of the main limiting factors for horticulture and must be considered before setting up an enterprise. The probability (years in 10) of air frost during the spring (1 Apr - 2 June) for Manston and Goudhurst are shown in Figs 3(a) and 3(b) respectively.

iii. Accumulated Day-Degrees

Plant growth in this country becomes appreciable when the mean daily air temperature exceeds about 6°C (called the base temperature). Accumulated day-degrees above 5.6°C give a useful indication of the potential plant growth in any given area.

A mean air temperature of 15.6°C for 1 day, for example, represents 10 day-degrees as does a mean air temperature of 10.6°C for 2 days. Values for the main fruit growing areas of England are shown in table 3.

* Figures are available for any long period climate station

Table 3

Mean annual values of accumulated day-degrees above 5.6°C for the period 1959-78

	Height (m)	Mean annual accumulated day-degrees
Goudhurst	85	1775
East Malling	39	1888
Gillingham	4	2080
Throwley	150	1714
Faversham	48	1851
Dungeness	6	1907
Wye	56	1837
Manston	44	1888
Margate	16	2034
Penzance	19	2131
Stratford-upon-Avon	49	1785
Christchurch	4	1951
Terrington St. Clement	3	1748

It can be seen that figures for north coast stations within Kent compare very favourably with the south-west peninsula while inland areas appear to be no earlier than parts of the Midlands and East Anglia.

Ontaria heat units (OHU) calculated on a daily basis give an accurate assessment of the suitability of an area for growing maize. The system assumes that plant development varies parabolically with air temperature (above some base at which development is zero) as opposed to the day-degree system which assumes a linearresponse.

Experimental work has shown that the following values of Ontario Units are a reasonable guide to phenology for sites where purely local influences on air temperature are not predominant.

Crop Stages	Ontario Units May-Oct	°C days above 10°C
Sowing - silking	1400	400
Sowing - 25% whole crop dry matter, (Clamp silage, earliest sweet corn CV's suitable for picking)	2300	600
Sowing - 30% whole crop dry matter (Tower silage, most early sweet corn CV's suitable for picking)	2500	700
Sowing - grain moisture content of 40%. (Suitable for combining for grain).	2700	800

These are the minimum values which are required to achieve these stages. If the crop is to be worth growing in an area, then these values will have to be exceeded for as many years as is considered economically viable. Statistically this means the specification of the probability of exceeding these values.

The probability (years in 10) of exceeding 2300, 2500 and 2700 threshold values for agroclimatic areas * covering Kent and the main fruit growing regions of England are shown in table 4. (The boundaries of the agroclimatic areas are shown in Fig 4).

Table 4

Probability (years in 10) of the OHU total May-Oct exceeding the given threshold values

Area	2300			2500			2700		
	L	A	H	L	A	H	L	A	H
34	10	10	10	10	10	9	9	9	7
39W	10	10	9	9	9	8	8	7	4
39E	10	10	10	10	10	9	9	9	6
40	10	9	9	9	9	5	9	6	2
21	10	9	9	9	8	6	7	5	2
37S	10	10	10	10	9	9	9	8	7
23	10	10	9	9	9	8	6	6	4

L = Low level A = Average height H = High Level

These values show that all but the highest parts of Kent are suited to maize production with north Kent particularly so. Even so, great care should be taken to avoid cold or exposed plantings in all areas. The suggested areas for growing maize in Western Europe are shown in Fig 5.

iv. Soil temperatures and growing season

These two parameters are closely connected, the main growing season for grass being roughly the length of time that the 30 cm soil temperature remains above 6°C. The 1941-70 mean soil temperatures at 30 cm for 3 stations in Kent are shown in table 5. Values for sites in other areas are given in Appendix 1 (b).

* All values quoted for agroclimatic areas in this article are adjusted to the average heights of the areas

Table 5.

1941-70 Monthly mean 30cm soil temperatures

	Dover	Margate	Faversham
Height (m)	6	16	48
soil	loam	thin loam over chalk	mixed drift
JAN	4.8	4.5	3.9
FEB	4.8	4.4	4.0
MAR	6.3	5.8	5.3
APR	9.5	9.1	8.4
MAY	13.1	12.5	11.9
JUN	16.4	16.0	15.5
JUL	18.3	17.9	17.4
AUG	18.3	17.8	17.3
SEP	16.7	15.8	15.3
OCT	13.7	12.7	11.9
NOV	9.3	8.6	7.7
DEC	6.5	6.1	5.3
YEAR	11.5	10.9	10.3

The affect of the Atlantic on soil temperatures is clearly seen at Plymouth with monthly means up to 2°C warmer than inland Kent during the winter months. This point is further illustrated by the length of growing season in the extreme south-west which is up to 50 days more than the north coast of Kent on average.

In lowland areas near to the Kent coast, growth continues for almost 270 days (mid-March to mid-December) but decreases to under 240 days on the higher parts of the North Downs and is only bettered by the south-west peninsula and south coast. The mean dates and duration of growing season for agroclimatic areas in Kent, the Midlands, East Anglia, the south coast and south-west are given in table 6. The values for the lowest and highest places (ie. the range) within each area are also quoted.

Table 6

Mean dates, duration and range of growing season

Area	Average height (m)	Mean dates	Duration (days)	Range (days)
34	58	Mar 18 - Dec 11	268	245 - 282
38N	79	Mar 23 - Dec 6	258	236 - 278
39W	80	Mar 25 - Dec 6	256	235 - 265
39E	49	Mar 19 - Dec 13	269	245 - 281
40	83	Feb 20 - Jan 8	322	281 - 351
21	83	Mar 23 - Nov 29	251	235 - 259
37S	64	Mar 19 - Dec 12	268	257 - 284
23	33	Mar 26 - Nov 29	248	239 - 255

Soil temperatures are affected by height above sea level, slope and aspect: the corresponding decrease in growing season with height for example in Kent is 20 - 25 days per 100m increase in height.

v. Sunshine and radiation

The amount of sunshine will usually decrease with distance from the sea, with latitude and with height. The average monthly totals for Kent are shown in table 7 (see Appendix 1(c) for values in other areas).

Table 7

Average monthly totals (in hours), plus extremes, of bright sunshine, 1941-70

	East Malling			Whitstable			Margate		
	41m			6m			18m		
	Av	Highest	Lowest	Av	Highest	Lowest	Av	Highest	Lowest
JAN	48.1	85.0	23.0	51.3	84.1	22.8	51.9	83.6	23.2
FEB	65.7	121.1	23.0	70.7	144.4	28.2	71.7	142.6	29.4
MAR	117.2	176.1	65.3	123.0	181.1	63.1	130.5	182.0	71.7
APR	160.9	225.9	84.6	173.2	230.6	102.1	182.1	242.5	108.4
MAY	207.3	251.8	155.8	213.5	275.6	154.3	223.1	281.3	179.3
JUN	217.1	280.4	132.2	228.0	291.6	173.0	236.0	295.3	174.3
JUL	202.4	290.4	126.3	213.7	288.6	135.5	220.2	312.3	143.6
AUG	186.5	280.7	127.9	196.5	308.4	130.9	204.4	307.8	153.2
SEP	147.5	214.0	88.7	154.3	218.1	94.1	160.8	230.2	102.3
OCT	110.3	169.0	72.1	116.9	171.7	76.5	119.3	181.2	78.4
NOV	59.8	94.9	29.7	63.6	95.2	37.1	62.1	95.8	31.2
DEC	44.1	89.1	12.2	46.5	77.1	13.9	46.9	78.9	14.1
YEAR	1566.9	1935.5	1344.1	1651.2	2013.2	1416.3	1709.0	2029.3	1419.3

The east coast of Kent is one of the sunniest areas of mainland Britain with over 4.6 hours of sunshine per day on average in most places. Margate's annual average totals are slightly less than those of Penzance and even exceed those of Southampton near the south coast; during the summer months, however, Margate is the sunniest station of those considered.

It is important to remember however that these figures are for well exposed sites: sites surrounded by buildings, trees and high hills etc. will receive less sunshine.

Production of winter glasshouse crops is particularly dependent upon radiation levels during the winter months. The variation over the United Kingdom of the annual mean daily global irradiation on a horizontal surface is shown in Fig 6. (These terms, perhaps, require further explanation: global irradiaton is the amount of energy received over a stated interval of time on the earth's surface). The highest values of irradiation throughout the year are found in the extreme south west with the south coast and Kent coast close behind.

vi Windspeeds.

The prevailing wind taking the year as a whole is from the south-west while during the spring time cold north-easterly winds are the most frequent, often delaying crop development and sometimes hindering pollination, particularly in east Kent. Fig 7 illustrates the percentage frequency of wind direction at Manston while the actual averages for the period 1961-71 are shown in table 8.

Table 8

Percentage frequency of wind speed and direction at Manston, 1961 - 71.

Beaufort Force	Knots	350 -10	20 -40	50 -70	80 -100	110 -130	140 -160	170 -190	200 -220	230 -250	260 -280	290 -310	320 -340	All dir.
0	0													3.0
1	1- 3	0.3	0.3	0.3	0.2	0.3	0.3	0.4	0.4	0.3	0.5	0.6	0.4	4.3
2	4- 6	0.9	1.0	1.0	1.1	0.9	1.2	1.4	1.4	1.7	2.1	1.7	1.0	15.4
3	7-10	1.6	1.9	2.0	1.7	1.7	2.7	2.7	4.0	5.1	2.6	2.5	1.8	30.3
4	11-16	1.9	2.8	2.8	2.1	1.2	1.5	2.4	4.5	6.1	2.0	2.3	2.2	31.8
5	17-21	0.6	1.0	1.1	0.6	0.3	0.2	0.8	2.0	2.0	0.5	0.5	0.8	10.4
6	22-27	0.2	0.3	0.3	0.2	0.1	0.1	0.4	1.0	0.9	0.1	0.2	0.3	4.1
7	28-33	0^+	0^+	0.1	0.1		0^+	0^+	0.2	0.1	0^+	0^+	0.1	0.6
8	34-40			0^+				0^+	0.1	0^+	0^+		0^+	0.1
9	41-47								0^+					0^+
10	48-55													
Total 4kts or more		5.2	7.0	7.3	5.8	4.2	5.7	7.7	13.2	15.9	7.3	7.2	6.2	92.7

0^+ represents percentages less than 0.05 but greater than 0.0

Gales (and associated 'salt-burn') are mainly a coastal phenomenon (occurring about 20 days a year in Kent).

Inland however, one can expect gusts of over 75 mph on average once in every 5 years and over 90 mph on average once in every 50 years.

The exposed areas (Fig 2) occur mainly along the coast and along higher parts of the North Downs; the exposed coastal strip extends roughly from the Isle of Sheppey to Deal.

vii. Rainfall

The distribution of average annual rainfall (the term 'rainfall' includes sleet, snow, hail etc.) over S E England is shown in Fig 8. Annual totals vary considerably from over 850 mm on the higher parts of the Downs to less than 600 mm along parts of the extreme north coast; this variability being similar to that of the W. Midlands, Hampshire and the south coast (The south-west corner, however, receives over 1000 mm in most places, while East Anglia has a variability of 550 - 700 mm). Summer rainfall accounts for between 42 and 50% of the annual average in all parts. The average monthly totals for 10 sites in Kent are shown in table 9. (figures for other stations are available on request).

Table 9

Average monthly rainfall, 1941-70

Station	Grid East	Ref North	Ht (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Tunbridge W	5588	1393	101	75	59	52	49	55	52	60	72	69	75	94	81	793
Hadlow	5631	1491	22	61	50	43	45	48	46	53	62	61	63	75	65	672
Gillingham	5785	1693	4	52	43	39	41	44	45	52	57	57	58	67	56	611
Faversham	6007	1593	48	58	46	41	40	47	46	55	65	63	65	80	65	671
E. Malling	5711	1568	39	59	47	41	44	49	45	56	64	60	66	75	65	671
Sittingbourne	5891	1613	68	62	50	45	46	51	51	60	68	63	66	83	68	713
Throwley	5983	1518	150	74	60	51	49	57	55	66	78	69	80	98	80	817
Manston	6335	1666	44	54	44	35	34	39	40	52	54	51	65	81	56	605
Folkestone	6227	1358	39	66	55	44	41	46	40	64	62	61	76	95	70	720
Wye	6057	1469	56	66	56	45	44	51	45	59	70	61	75	93	74	739

Fig 9 shows the variation in monthly rainfall at East Malling for the period 1941 - 70. The black dots represent the median rainfall, half of the observations lying above this level and half below for any given month. The vertical bars indicate the inter-quartile range (iqr) ie. the central 50% of recorded rainfall values, while the crosses denote extremes of rainfall. Therefore May, with the smallest inter-quartile range and moderate extreme values, is the month of most reliable rainfall, whilst autumn rains are noticeably unreliable. A similar analysis for Tunbridge Wells (1951-70) showed that July was the month of most reliable rainfall whilst autumn, again, noticeably unreliable.

viii. Transpiration

Average values of potential transpiration (PT) from a green crop are of use in estimating the irrigation need on a day to day basis for a particular location; values for Kent are given in Table 10.

Table 10

Average monthly potential transpiration from a green crop, 1941 - 70.

Agroclimatic area	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	YEAR
34	33	57	84	99	99	80	51	22	542
38N	33	55	81	99	98	79	48	22	531
39W	33	56	81	100	98	79	50	20	532
39E	33	58	85	102	100	81	51	25	563

ix. Soil moisture deficit and irrigation need

Soil moisture deficit (SMD) is defined as the amount of rainfall or irrigation required to restore the soil to field capacity. End of month SMD frequencies and actual values under a complete cover of short rooted vegetation (eg. grass) for several sites in Kent are shown in Appendix 2.

Research has shown that for each type of crop there is a critical maximum SMD beyond which yield potential is likely to be reduced even if subsequent irrigation or rainfall is adequate. On this basis, the water need for various crops in Kent are given in Appendix 3 (which also includes some explanatory notes); for calculations of long-term irrigation needs for individual sites, reference should be made to Technical Bulletin 138 on irrigation (currently being updated). Thus, for the majority of crops grown, irrigation will be required in 19 years out of 20, although the amount of water to be applied will depend upon the scheme being followed.

x. Potential spring work days

These are defined as days on which the soil moisture content is such that machinery can be used for working down, seed bed preparation etc. with minimal risk of damaging the soil structure.

The potential work days for spring were calculated for Hadlow (1967-78), Manston (1963-77) and Faversham (1959-77) under three soil types using an empirical model developed by Smith (1968) for the E. Midlands based on daily rainfall figures. Ogives were plotted (Fig 10) of the frequency of occurrence of total work days (March - May) below given limits; the median and iqr's are shown in table 11.

Table 11

Potential spring work days

Station	Period	Median			Iqr		
		Heavy	Medium	Light	Heavy	Medium	Light
Hadlow	1967-78	62	71	83	50-74	60-83	73-94
Manston	1963-77	59	67	77	50-73	59-80	68-87
Faversham	1959-77	38	46	57	32-47	41-55	51-65

Hampshire and the south coast are likely to be similar to Kent, in contrast to the south-west peninsula where heavier rainfall and relatively long periods with the soil at capacity can severely affect spring fieldwork operations.

LEGEND

Figure 1: average daily maximum and minimum temperatures for Dover, East Malling and Penzance, 1941-70.

" 2: areas of frost liability and exposure to strong winds.

" 3(a): probability (years in 10) of air frost during spring (1 Apr - 2 Jun) for Manston.

" 3(b): as 3(a) for Goudhurst.

" 4: map of agroclimatic areas in England and Wales.

" 5: Maize in north west Europe.

" 6: the variation over the United Kingdom of the mean annual daily global irradiation on a horizontal surface (in MJ/M^{-2}).

" 7: percentage frequency of winds with direction at Manston.

" 8: map of average annual rainfall (1941-70).

" 9: variation in monthly rainfall at E Malling, 1941-70.

" 10: ogives of potential spring work days at Hadlow, Manston and Faversham.

References

Ministry of Agriculture, Fisheries and Food (MAFF), (1976). The Agricultural Climate of England and Wales. Technical Bulletin No. 35. HMSO London.

MAFF Technical Bulletin No. 138. Irrigation. HMSO London.

Hogg, W.H. (1963) The Climatic aspects of horticulture in the south-east region. Agricultural memorandum No. 67.

Starr, J.R. personal communication.

Hogg, W.H. (1967) Atlas of long term irrigation need in England and Wales (MAFF).

Met. O. 883 (1976) Averages of temperature for the United Kingdom 1941-70. HMSO London.

Met. O. 884 (1976) Averages of bright sunshine for the United Kingdom 1941-70. HMSO London.

Met. O. 856C (1972) Tables of temperature, relative humidity, precipitation and sunshine for the world. Part 111. Europe and the Azores. HMSO London.

Met. O. 912 (1980) Solar radiation data for the United Kingdom 1951-75. Meteorological Office, London Road, Bracknell, Berks. RG12 2SZ.

Climatological memorandum 77. (1975). Averages of earth temperature at 30cm depth for the United Kingdom 1941-70. Meteorological Office, London Road, Bracknell, Berks.

Roe, C.P. (1980). Frequency of radiation and wind frosts during spring in S.E. England. Agricultural memorandum 883.

Rumney, R.P. (1969) An analysis of the potential frost risk during April and May of the main fruit growing areas of England. Agricultural memorandum 275.

Hough, M.N. (1978) Ontario unit map of Britain. Agricultural memorandum 825.

Roe, C.P. (1979) Meteorological survey of old O.S. sheet 172. Unpublished paper for ADAS Land Service Department, MAFF, Coley Park, Reading.

Roe, C.P. (1980) Meteorological survey of West Kent (old O.S. sheet 171). Unpublished paper for ADAS Land Service Department.

Roe, C.P. (1980) Meteorological survey of East Kent (old O.S. sheet 173). Unpublished paper for ADAS Land Service Department.

Any comments or suggestions should be made to the author.

C P ROE
Meteorological Office
MAFF, Reading.

September 1980.

PC

Appendix 1(a)

Average daily maximum, minimum and mean temperatures °C 1941 - 70 for the main fruit growing areas of England and the near continent.

	Southampton 3m			Stratford-upon-Avon (1) 49m			Terrington St. Clement (2) 3m			Penzance 19m			Vlissingen (3) 51°28'N 3°35'E 1m		
	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean
JAN	7.4	1.6	4.5	6.1	-0.1	3.0	5.4	0.3	2.9	9.4	4.5	6.9	5.0	1.0	3.0
FEB	8.0	1.7	4.9	6.8	0.1	3.5	6.3	0.4	3.3	9.2	3.9	6.5	5.1	0.6	2.9
MAR	10.9	2.9	6.9	10.1	1.1	5.6	9.5	1.7	5.6	10.8	5.3	8.1	8.5	2.5	5.5
APR	14.2	5.2	9.7	13.4	3.4	8.4	13.0	4.0	8.5	13.0	6.6	9.8	11.9	5.4	8.7
MAY	17.4	7.8	12.6	16.7	5.9	11.3	16.1	6.5	11.3	15.3	8.8	12.1	15.9	8.7	12.3
JUN	20.5	10.9	15.7	20.0	9.0	14.5	19.3	9.4	14.3	18.1	11.2	14.7	19.0	12.0	15.5
JUL	21.8	12.7	17.3	21.4	10.9	16.1	20.8	11.4	16.1	19.5	12.8	16.1	20.6	14.1	17.4
AUG	21.5	12.6	17.1	21.0	10.7	15.9	20.6	11.2	15.9	19.5	12.9	16.2	20.9	14.4	17.7
SEP	19.5	10.7	15.1	18.7	9.0	13.7	18.6	9.6	14.1	17.9	11.9	14.9	18.7	12.6	15.7
OCT	15.9	8.0	11.9	14.8	6.0	10.4	14.6	6.8	10.7	15.3	9.9	12.6	14.1	8.9	11.5
NOV	11.1	4.5	7.8	9.7	2.9	6.3	9.3	3.3	6.3	12.1	6.9	9.5	9.4	5.2	7.3
DEC	8.5	2.6	5.5	7.2	0.8	4.0	7.1	1.3	4.2	10.4	5.6	8.0	6.3	2.4	4.4
YEAR	14.7	6.8	10.7	13.8	5.0	9.4	13.4	5.5	9.5	14.2	8.4	11.3	13.0	7.3	10.2

(1) data averaged over 1941-47, 51-70
(2) data averaged over 1941-46, 51-70
(3) data averaged over 1931-60

Appendix 1(b)

1941-70 monthly mean 30cm soil temperatures

	Leckford	Edgbaston	Terrington St Clement	Plymouth Hoe
height (m)	117	163	4	36
soil	thin loam over chalk	earth and cinders	medium silt over sandy silt	loam
JAN	4.0	4.9	3.7	5.9
FEB	4.0	4.7	3.7	5.8
MAR	5.2	5.4	5.1	7.1
APR	8.1	7.1	8.0	9.9
MAY	11.3	9.2	11.2	12.8
JUN	14.6	11.8	14.7	15.7
JUL	16.4	13.2	16.4	17.3
AUG	16.1	13.5	16.1	17.2
SEP	14.2	12.6	14.4	15.7
OCT	11.2	10.7	1 .5	13.0
NOV	7.6	7.9	7.8	9.6
DEC	5.3	6.2	5.2	7.4
YEAR	9.8	8.9	9.8	11.5

Appendix 1(c)

Average monthly totals, plus extremes, of bright sunshine, 1941-70

	Southampton			Stratford-upon Avon			Terrington St. Clement (1)			Penzance			Vlissinge (2
	58m			57m			5m			45m			1m
	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average
JAN	56.5	98.0	28.9	46.2	81.9	18.8	51.7	92.4	23.9	60.4	85.6	27.5	53
FEB	73.5	123.8	31.1	65.1	107.6	15.1	66.9	121.1	16.6	82.6	132.1	32.8	69
MAR	124.5	176.8	66.7	106.1	171.4	52.7	114.9	174.9	54.7	129.3	191.0	74.3	130
APR	172.9	225.3	90.5	147.4	221.6	84.1	158.2	230.6	94.7	190.3	246.3	132.8	166
MAY	211.8	267.6	158.6	181.2	246.2	97.6	199.6	287.7	157.3	222.5	297.9	166.1	211
JUN	218.3	302.4	147.6	190.4	292.7	113.5	195.5	269.4	99.4	218.9	281.0	168.8	224
JUL	204.9	301.7	119.2	173.6	255.6	109.0	179.8	251.4	111.6	211.7	314.2	134.1	204
AUG	189.0	245.3	135.8	163.3	263.1	110.8	171.4	255.8	155.2	198.9	277.4	140.3	195
SEP	145.6	246.5	87.9	127.7	183.3	64.2	137.8	212.9	92.8	157.1	254.5	80.5	147
OCT	113.9	161.5	61.9	93.4	133.3	54.7	104.1	175.4	65.0	114.0	149.9	67.6	101
NOV	68.1	93.6	37.6	53.3	79.9	22.5	60.0	95.1	40.7	75.4	114.3	41.0	51
DEC	53.8	88.1	22.9	45.0	68.2	19.7	44.0	87.7	13.5	58.8	98.2	41.5	37
YEAR	1632.8	2055.6	1402.0	1392.7	1647.2	1094.6	1483.9	1812.4	1253.8	1719.9	2050.1	1524.9	1588

(1) data for 1941-46, 51-70

(2) data for 1931-60. Highest and lowest values not available.

Appendix 2

End of month soil moisture deficit frequencies (grassland model)

	mm	J	F	M	A	M	J	J	A	S	O	N	D
East Malling (1941-70)	0	30	30	16	9	1	1			2	8	20	29
	1-25			11	8	3				2	4	5	
	26-50			3	10	10	2		3	2	3	3	1
	51-75				3	12	7	2	3	2	7	1	
	76-100					4	13	15	8	11	4		
	101-125						7	13	16	11	4	1	
Goudhurst (1941-70)	0	30	29	21	10	2	1		3	6	15	26	30
	1-25			6	9	7		1	1	3	5	2	
	26-50			3	10	9	5	2	5	4	1	1	
	51-75				1	10	9	7	4	6	7		
	76-100					2	8	11	6	4	1	1	
	101-125						7	9	11	7	1		
Tunbridge Wells (1941-63)	0	23	23	15	3				2	4	9	19	22
	1-25			5	9	4	1		1	3	5	3	
	26-50			3	9	6	3	1	2	1	4		1
	51-75				2	10	4	2	4	6	3		
	76-100					3	10	12	2	4	1		
	101-125						5	8	12	6	1	1	

Mean soil moisture deficit at end of month

	J	F	M	A	M	J	J	A	S	O	N	D
East Malling (1941-70)	0	0	7	23	50	80	98	96	82	48	12	1
Goudhurst (1941-70)	0	0	5	19	41	71	88	77	58	25	5	0
Tunbridge Wells (1941-63)	0	0	6	20	40	70	90	83	68	31	4	1
Gillingham (1951-65)	4	1	8	25	52	80	98	103	80	62	27	9
Maidstone (1941-70)	4	5	9	24	53	86	101	100	86	60	25	11
Dymchurch (1941-70)	4	5	9	27	59	90	103	102	86	53	21	9

Appendix 3

Irrigation need in Kent (mm)

Trend of county SW-NE, need increasing towards NE

	Plan	Adj. total need	Mean adj. need	5th driest	No. of years in which irrigation is required.
GRASS (Apr - Sep)	1	3700 - 4700	190 - 250	230 - 310	19
	2	3225 - 4140	170 - 220	225 - 265	19
MAINCROP POTATOES (Jun - Aug)	1	2745 - 3125	145 - 165	175 - 190	19
	2	2285 - 2920	120 - 150	150 - 185	19
EARLY POTATOES (May - Jun)	1	1470 - 2160	75 - 115	95 - 115	19
CEREALS (May - Jun)	3	940 - 1400	75 - 80	75 - 90	12-19
(Apr - Jun)	1	1930 - 2670	100 - 140	140 - 155	19
	2	1525 - 2390	80 - 125	115 - 130	19
(May - Jun)	1	1470 - 2160	75 - 115	95 - 115	19
	2	1220 - 1730	70 - 100	90 - 115	17
APPLES & BLACK-CURRANTS (May - Aug)	1	3225 - 3940	170 - 205	215 - 245	19
	2	2970 - 3885	155 - 205	215 - 235	19
	3	2413 - 3225	125 - 170	180 - 215	19
	4	1650 - 2660	105 - 140	120 - 190	16-19
RADISH (Apr - Aug)	1	3760 - 4395	200 - 230	230 - 260	19
STRAWBERRIES - FRUITING (May - Jun)	1	1470 - 2160	75 - 115	95 - 115	19
	2	1220 - 1730	70 - 100	90 - 115	17
(Aug - Sep)	1	685 - 890	40 - 45	50 - 65	16-19
	2	380 - 635	55 - 65	65	7-10
RASPBERRIES (Jun - Jul)	1	1955 - 2335	100 - 125	125 - 135	19
	2	1475 - 1980	75 - 105	100 - 135	19
	3	1145 - 1295	70	70 - 95	16-19
ONIONS - SALAD (Apr - Aug)	1	3760 - 4395	200 - 230	230 - 260	19
HOPS (May - Jul)	1	2465 - 3125	130 - 165	150 - 190	19
	2	1980 - 2870	105 - 150	145 - 180	19
	3	1475 - 2085	75 - 110	120 - 140	19

Notes

1. The 'mean adjusted need' is based on the 'adjusted total need' in 20 years. ie. it is the average annual need if the year with the 5th greatest water requirement is taken as the year of maximum need. The information thus ignores the 4 driest years which are assumed to require the same amount of irrigation as was required during the 5th driest year. Irrigation planning is often based on the mean adjusted need and on the 5th driest year; it is clearly not reasonable to plan for the driest year in 20 and indeed such a figure can be misleading.

2. The four irrigation plans used are as follows:

   Plan 1. soil restored to capacity whenever SMD becomes 25 mm

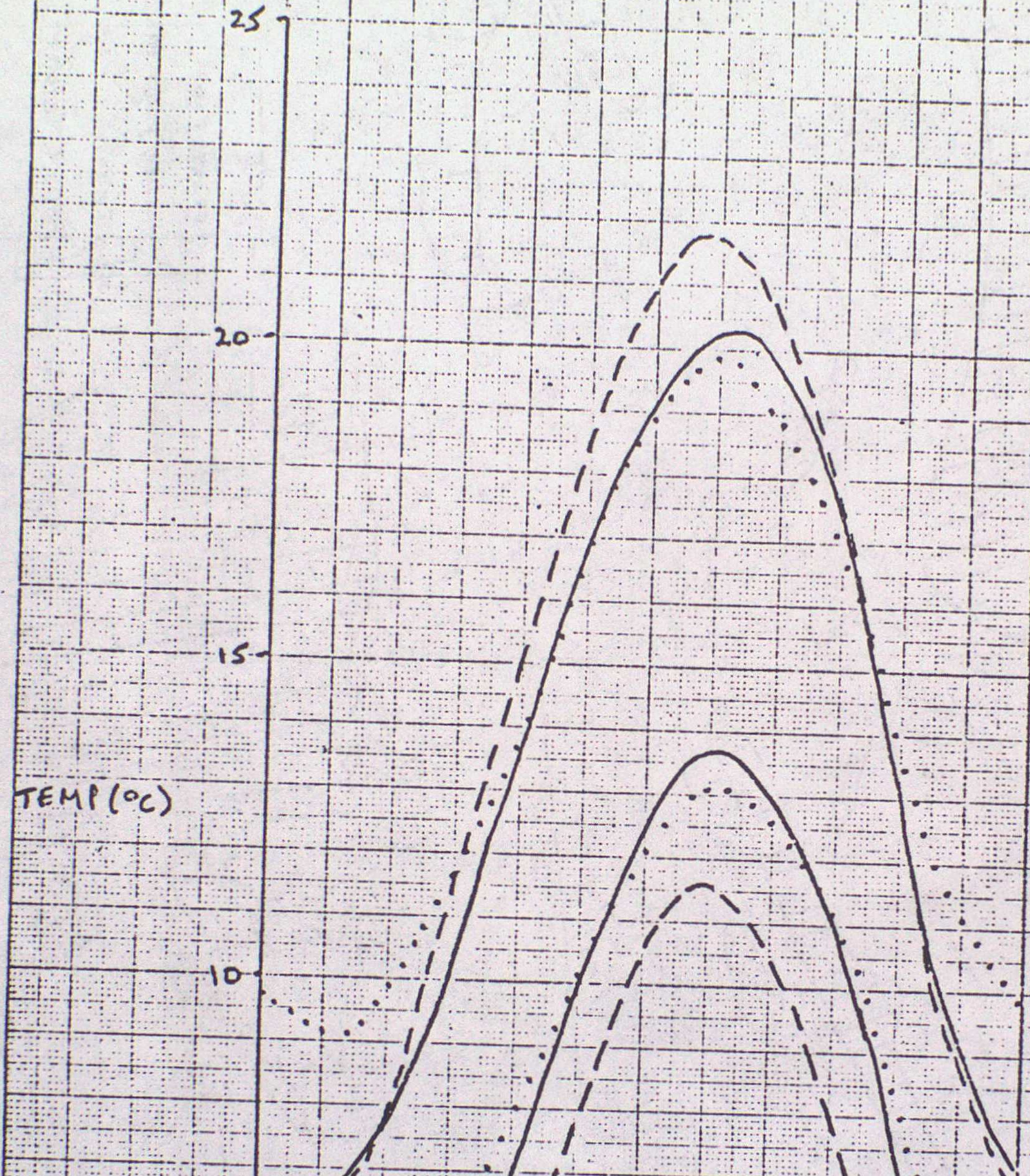
   Plan 2. soil restored to capacity whenever SMD becomes 50 mm

   Plan 3. SMD reduced to 25 mm when it reaches 75 mm

   Plan 4. SMD reduced to 50 mm when it reaches 125 mm

3. Excluding upland areas, the errors in the above values are not likely to exceed 250 mm for the adjusted total needs over 20 years; for the total number of years when irrigation is needed the maximum error is 1 year out of 20. Thus the greatest error occurs in the mean adjusted need which depends upon the error in the total adjusted need and the total number of years figures.

   In upland areas the irrigation needs will be less than those quoted due to the increased rainfall and lower transpiration rates.



MEAN DAILY MAXIMUM AND MINIMUM TEMPERATURES FOR 1941-70

FIG 1

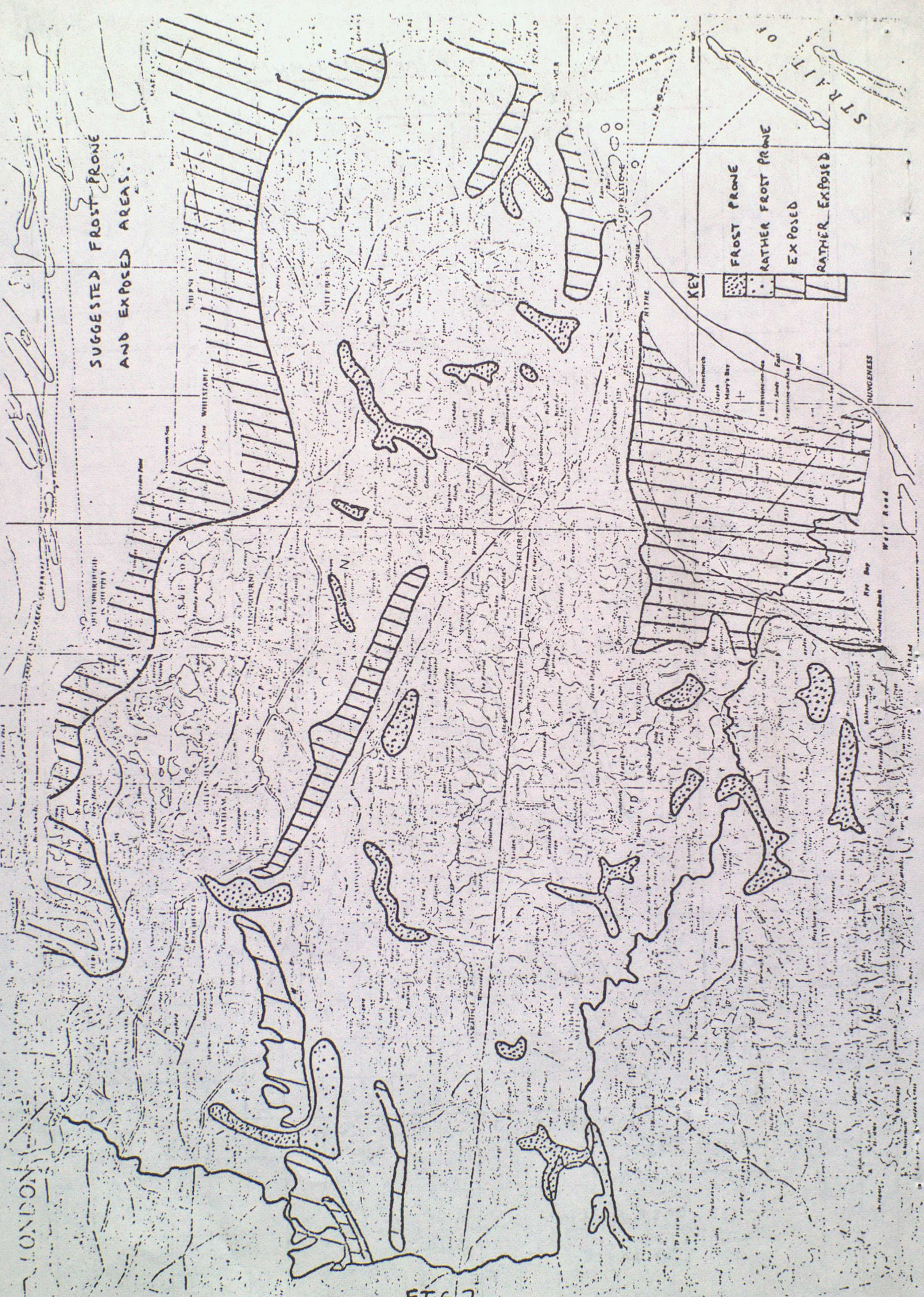

SUGGESTED FROST PRONE
AND EXPOSED AREAS.
KEY
FROST PRONE
RATHER FROST PRONE
EXPOSED
RATHER EXPOSED
STRAIT OF
FOLKESTONE
HYTHE
DUNGENESS
WHITSTABLE
CHATHAM
ASHFORD
LONDON

FIG 2

Manston 1961-77
Probability of Air Frost during Spring

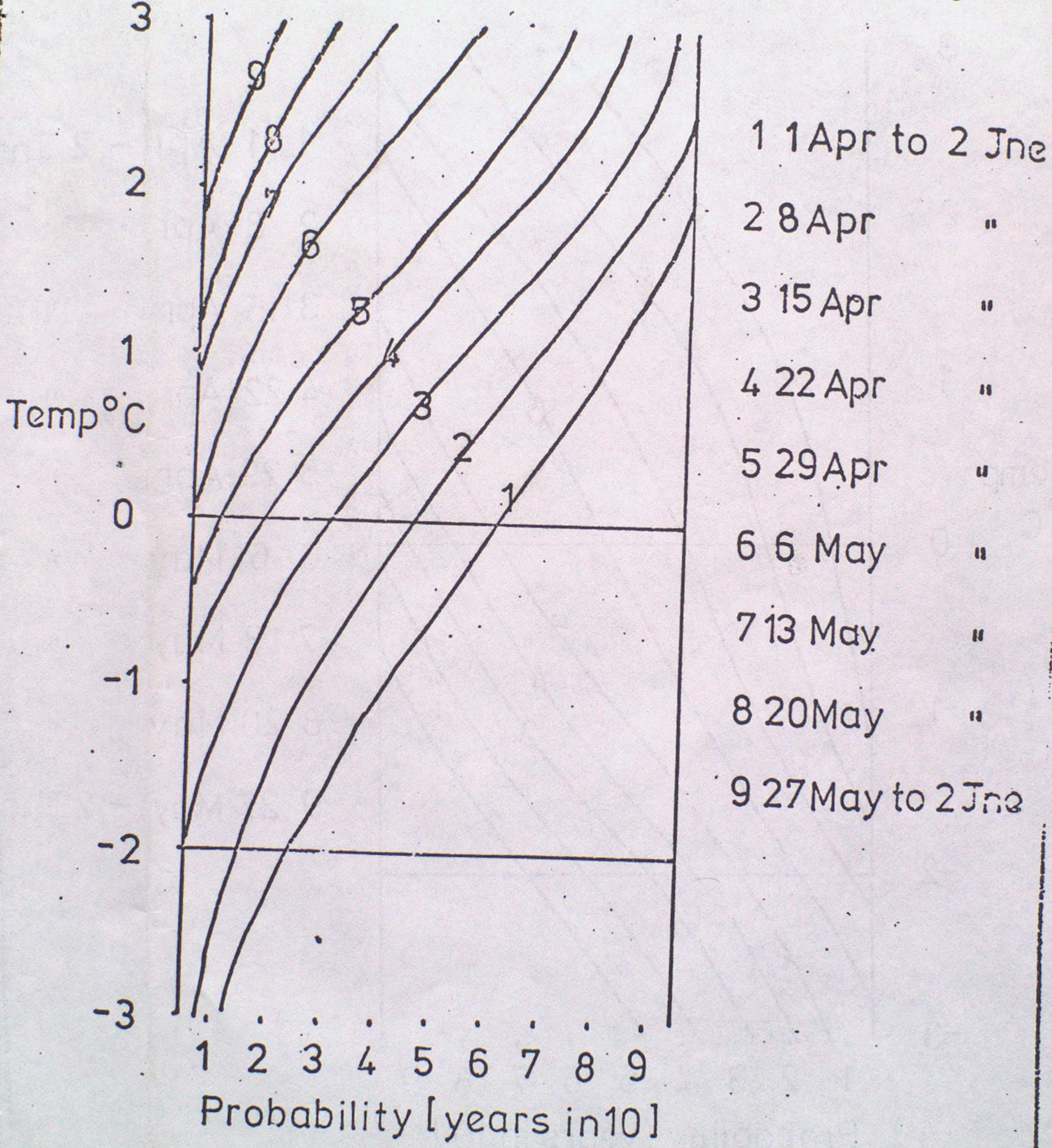


FIG 3(a)

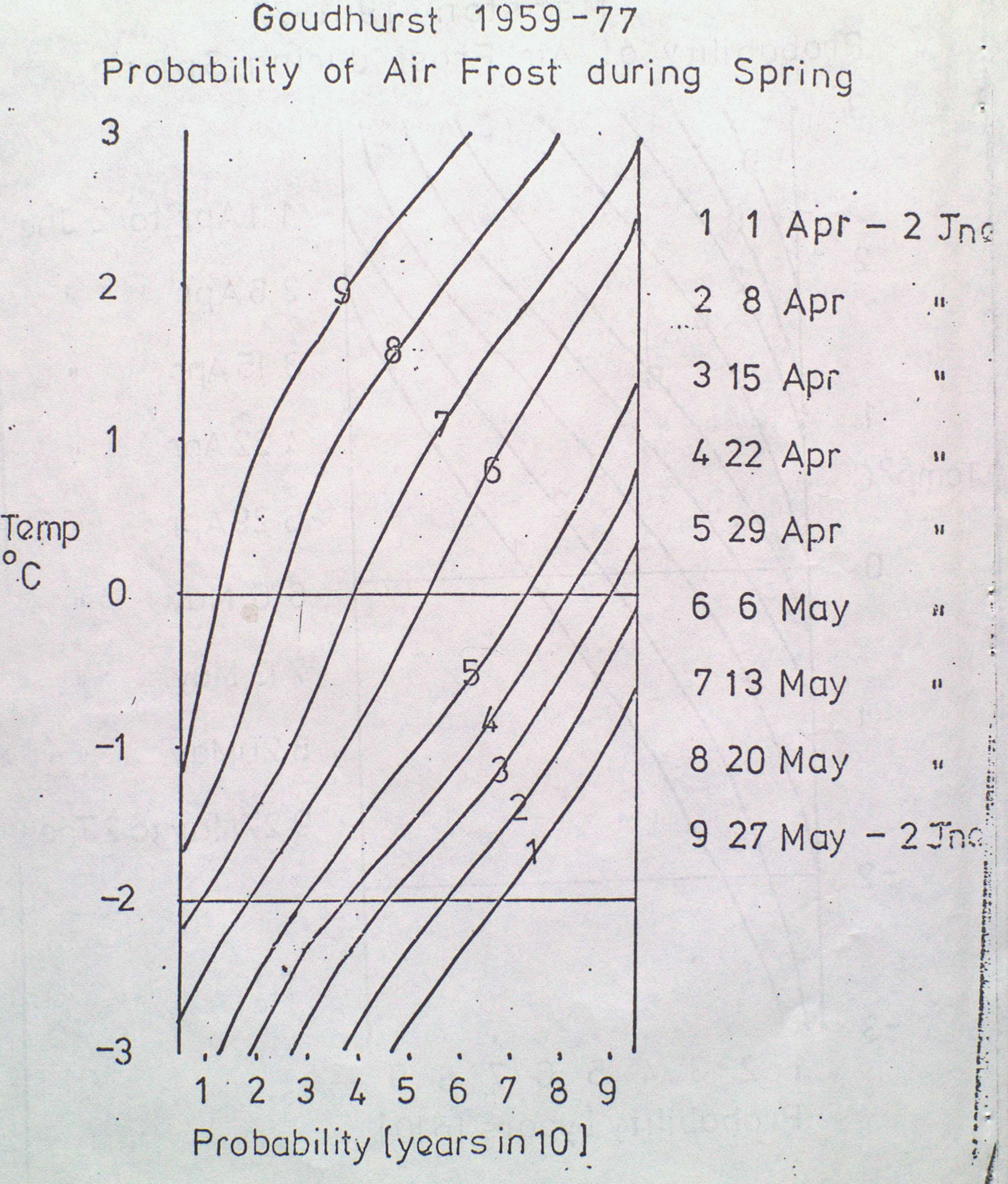
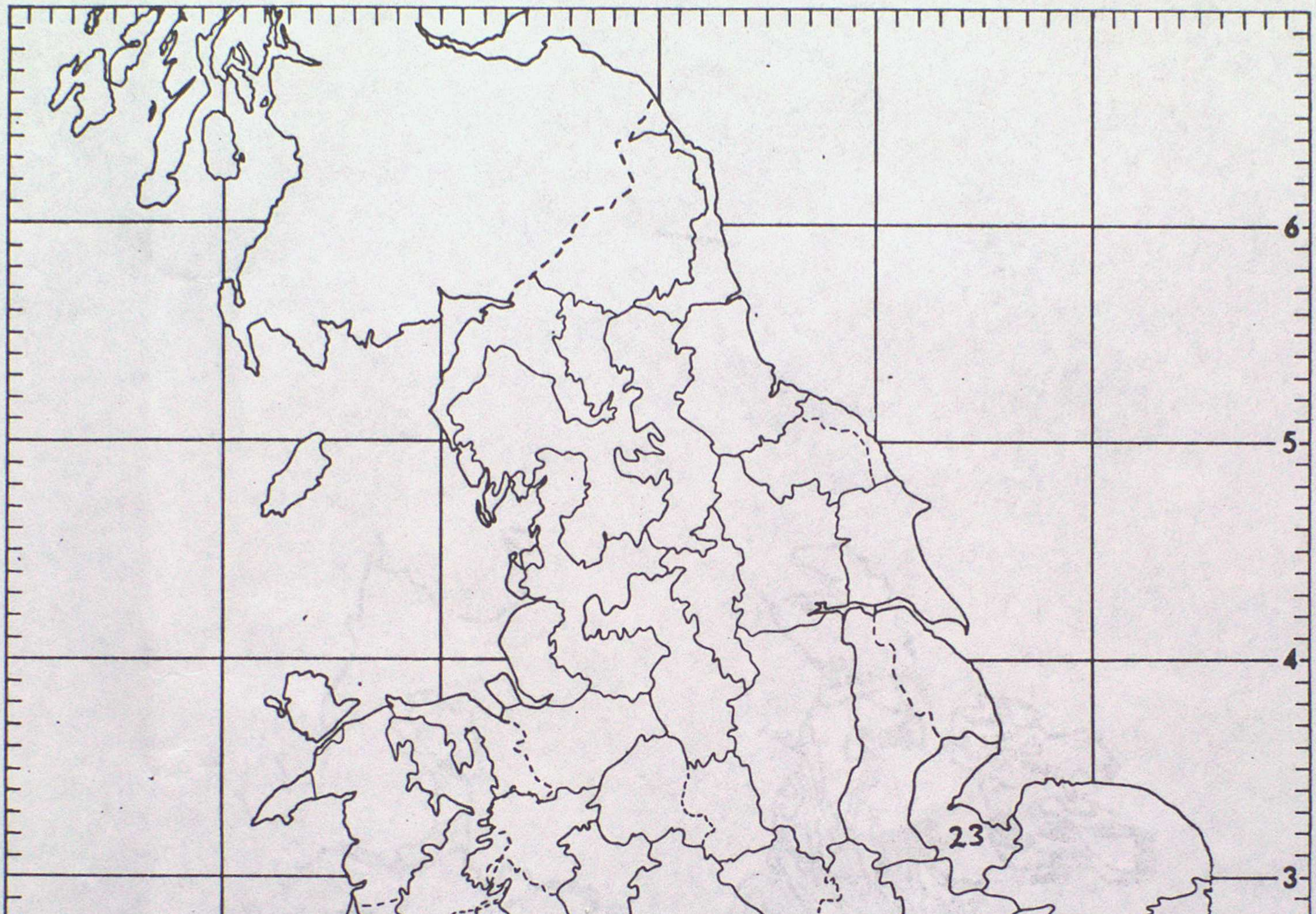
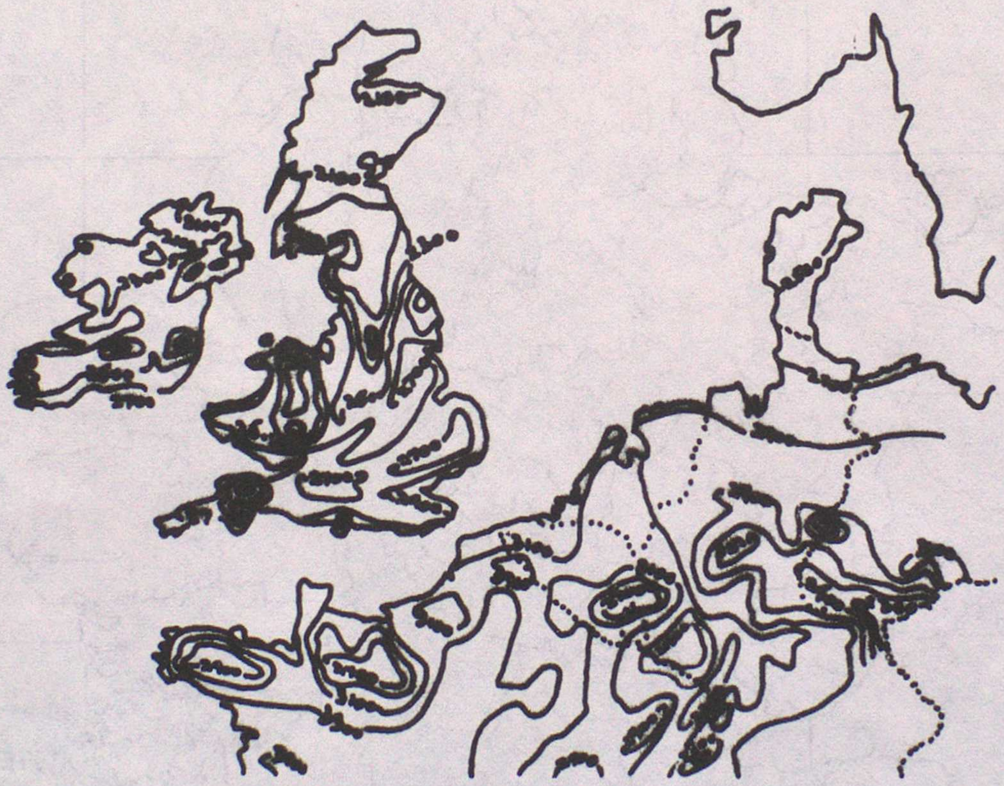

Goudhurst 1959-77
Probability of Air Frost during Spring
Temp °C
3
2
1
0
-1
-2
-3
1 2 3 4 5 6 7 8 9
Probability [years in 10]
9
8
7
6
5
4
3
2
1
1 1 Apr - 2 Jne
2 8 Apr "
3 15 Apr "
4 22 Apr "
5 29 Apr "
6 6 May "
7 13 May "
8 20 May "
9 27 May - 2 Jne

FIG 3(b)


6
5
4
3
2
1
23
21
34
39W
39E
38N
37S
40
KILOMETRES
0 20 40 60 80
0 10 20 30 40 50
STATUTE MILES
2
3
4
5
6 NATIONAL GRID

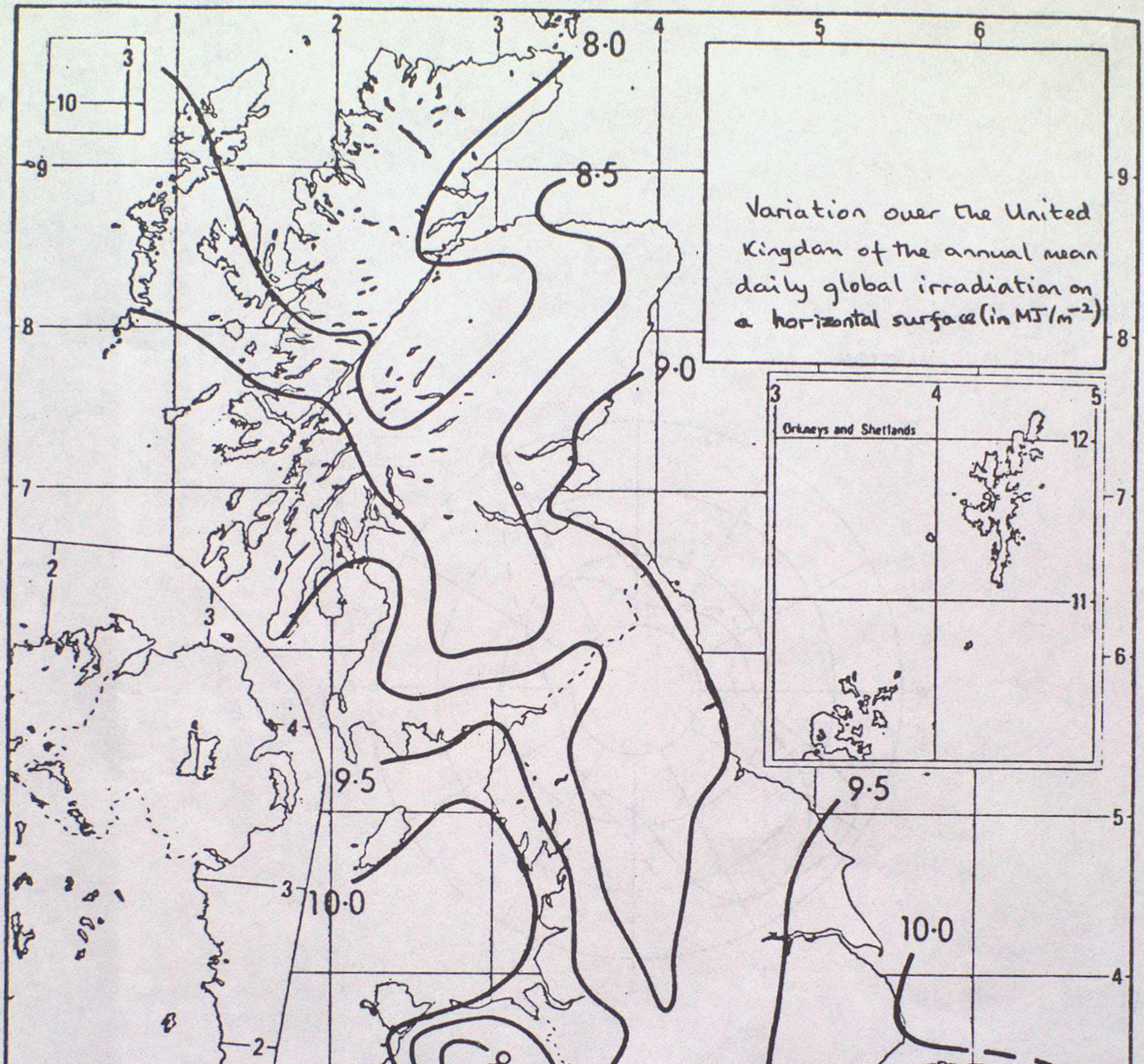
AGROCLIMATIC AREAS FOR ENGLAND AND WALES

FIG 4



Isopleths showing average seasonal (May 1 – Oct 31) totals of Ontario Units in NW Europe

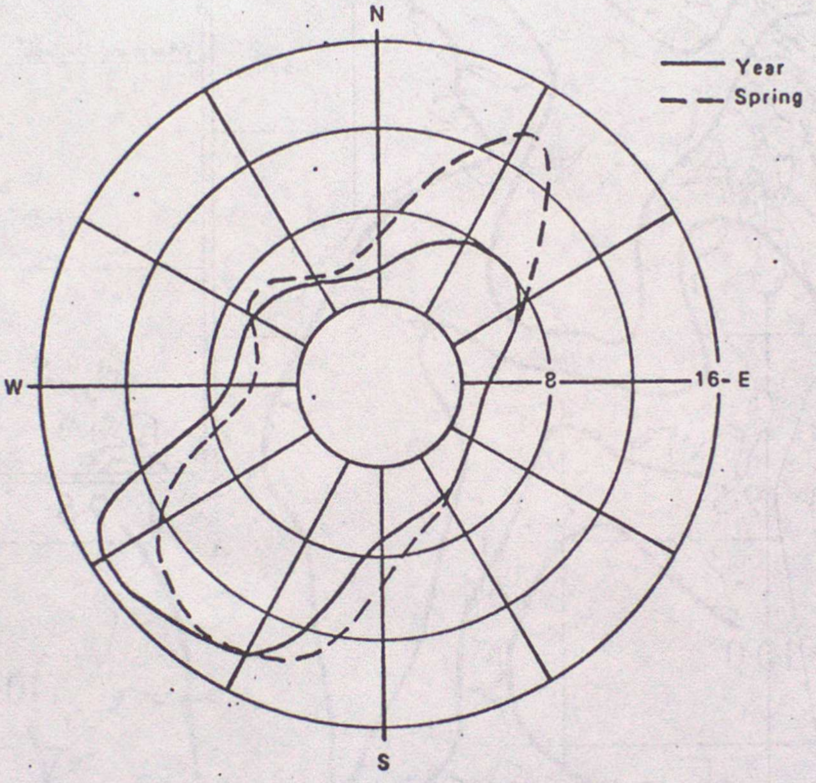
FIG 5


8·0
8·5
9·0
9·5
10·0
9·0
10·5
11·0
9·5
10·0
9·0
10·5
11·0
Orkneys and Shetlands
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
UTM GRID ZONE 30
55
54

Variation over the United Kingdom of the annual mean daily global irradiation on a horizontal surface (in MJ/m^{-2})

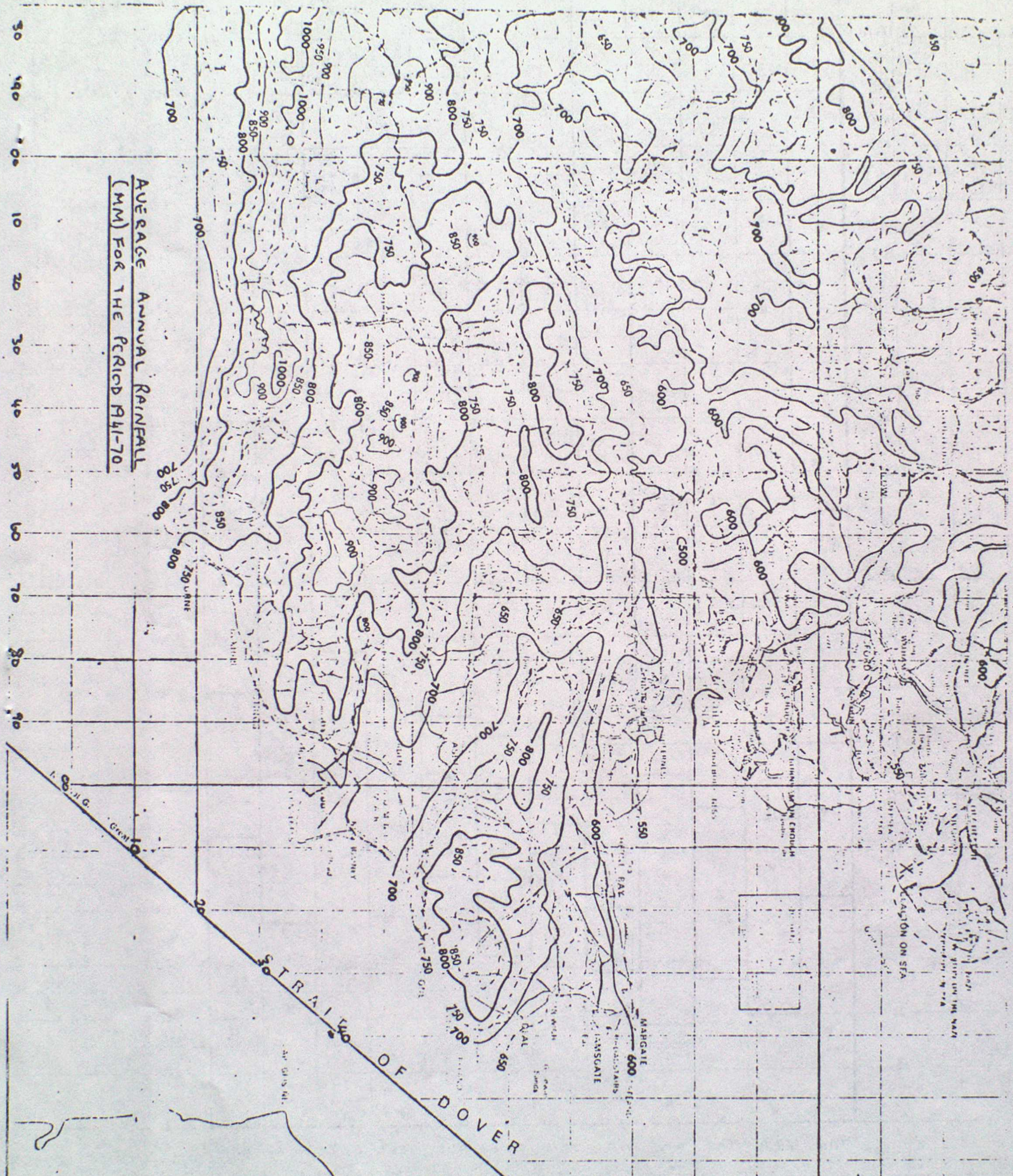
FIG 6

MANSTON



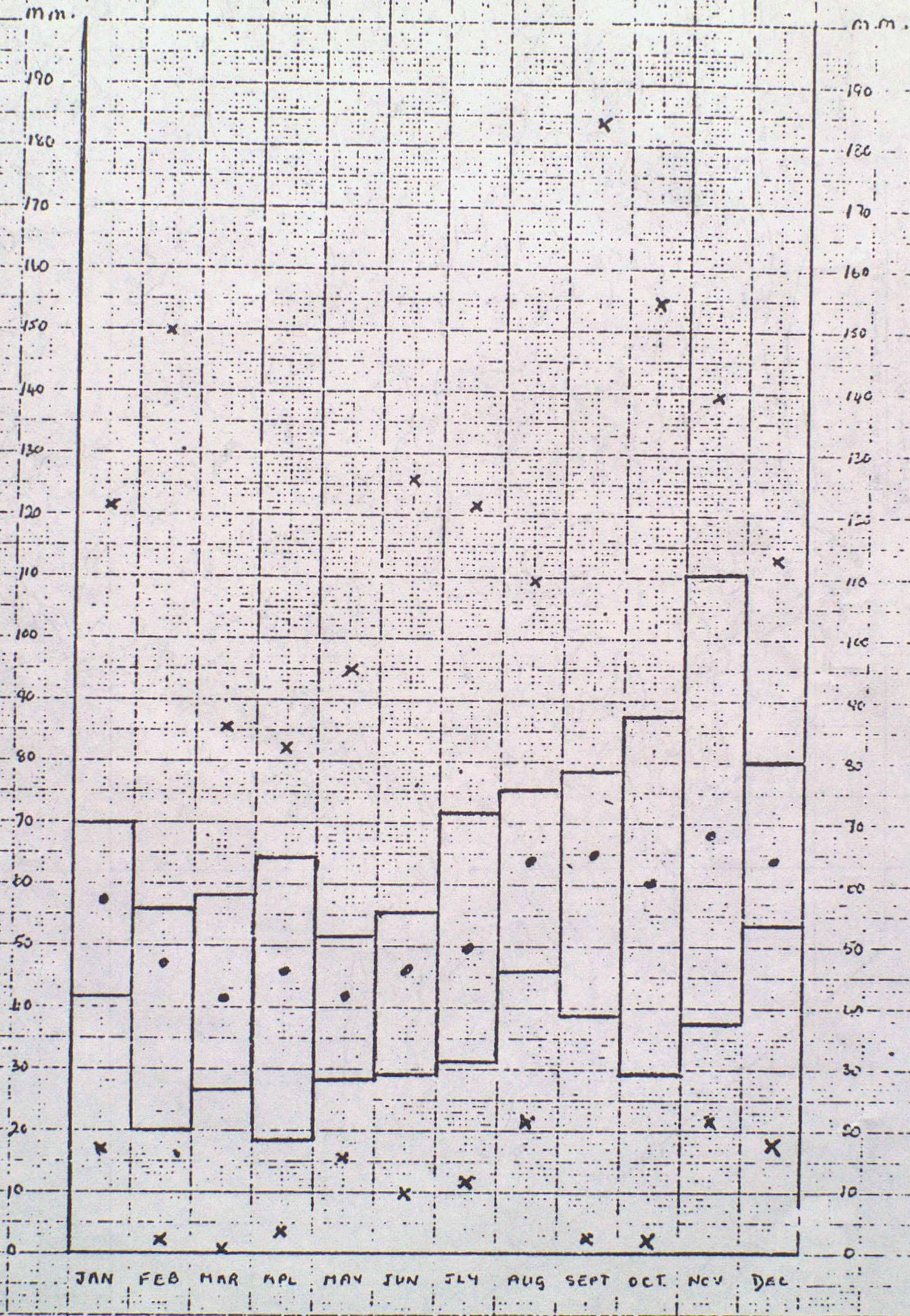
Frequency (%) of wind direction
(excluding winds under 4 knots)

FIG 7


AVERAGE ANNUAL RAINFALL (MM) FOR THE PERIOD 1941-70

STRAIT OF DOVER
MARGATE
RAMSGATE
CLACTON ON SEA
1000
900
850
800
750
700
650
600
550
500

FIG 8



VARIATION OF MONTHLY RAINFALL AT E. MALLING.

(1951 - 70)

FIG 9

POTENTIAL LAND WORK DAYS

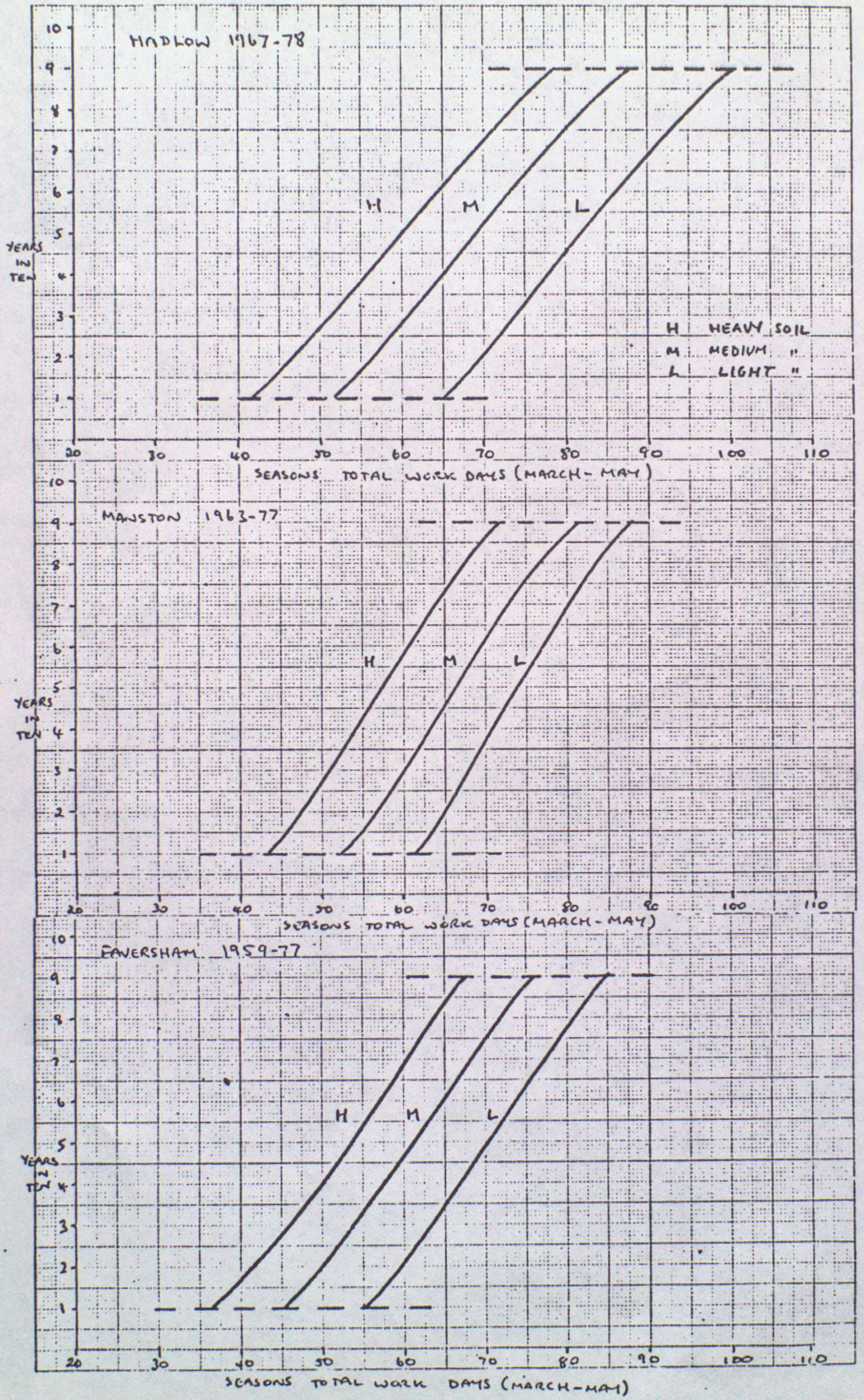


FIG 10